

# Solar Eclipses: What They Are, Front Line Experiences, and Some Science

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# Today's Discussion:

- Overview of eclipses.
- The 21 August 2017 total solar eclipse.
- Eye safety.
- A couple of experiences from the “front line” of past eclipses.
- The motivation for doing solar eclipse studies (just an outline...).
- Things you can do.

# What are Eclipses?

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# Lunar Eclipse



**Sun**

**Earth**



**Moon**

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- Solar eclipses.

# What are Eclipses?

- One body falls into the shadow of another.
- Lunar eclipses.
- Solar eclipses.
  - Partial.
  - Annular.
  - Total.

# Solar Eclipse





The moon's orbit is tilted.



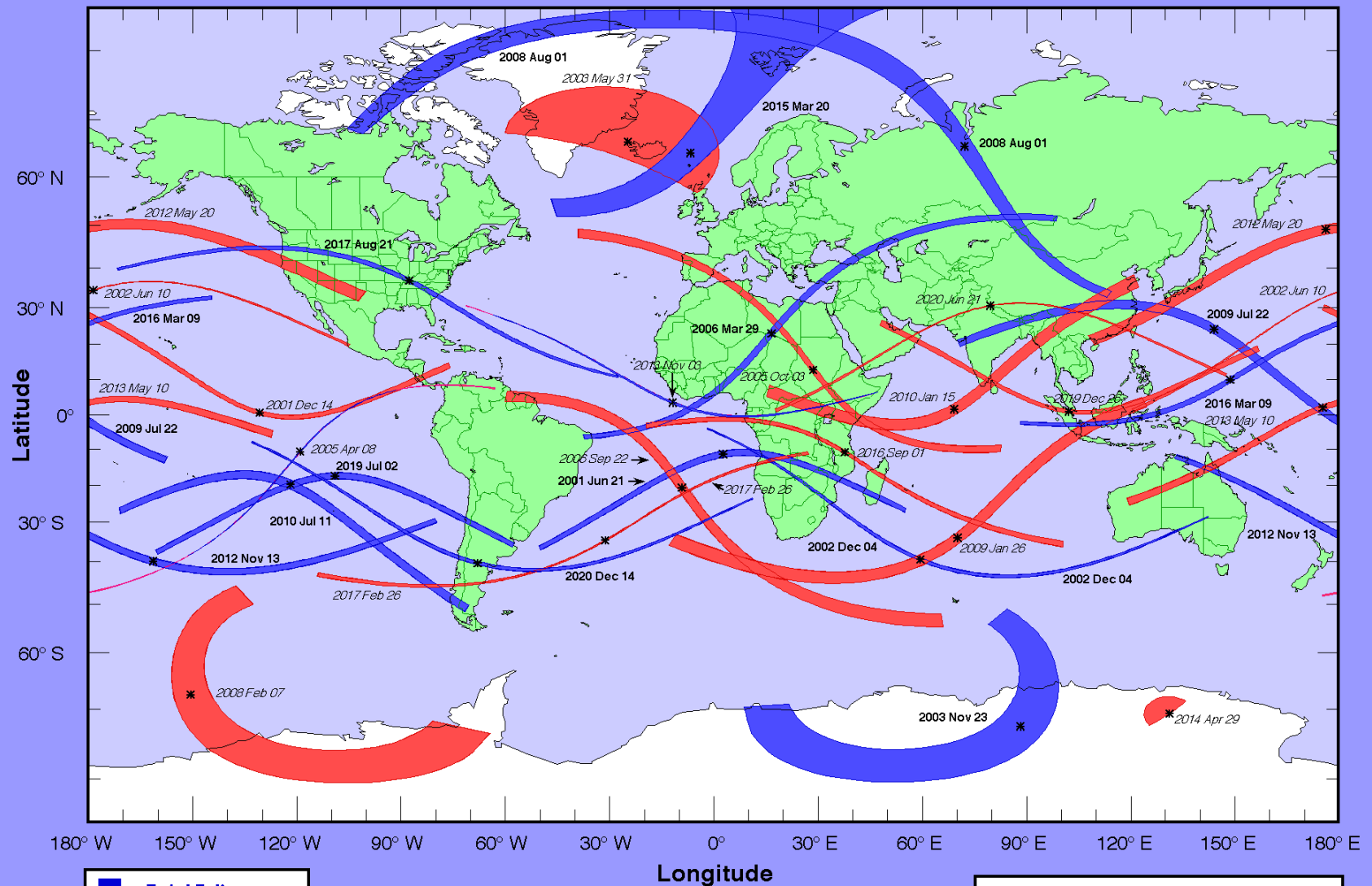
# Solar Eclipse





20 May 2012 22:35:02 UT

# Total and Annular Solar Eclipse Paths: 2001 – 2020



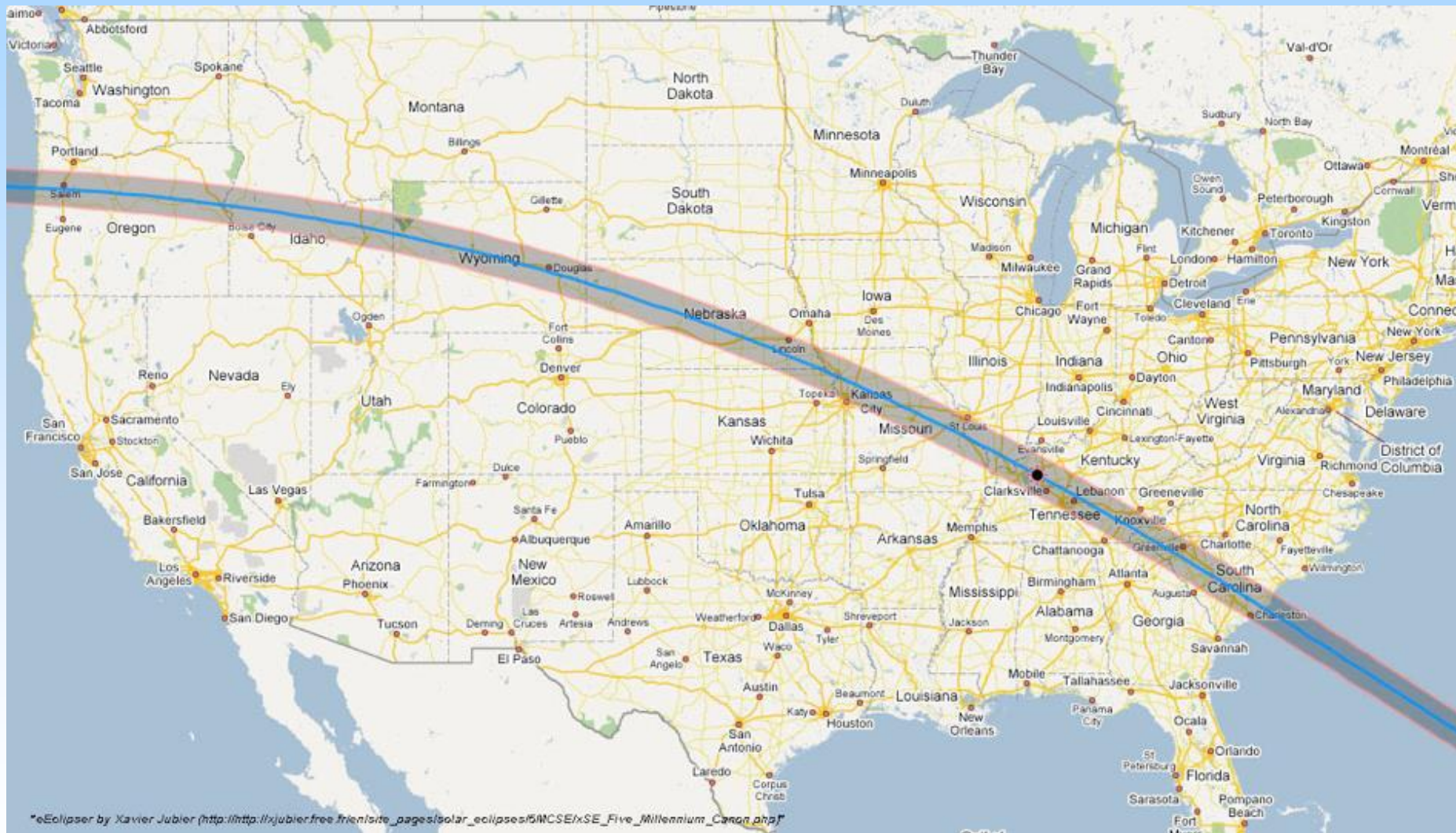
[sunearth.gsfc.nasa.gov/eclipse/eclipse.html](http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html)

Fred Espenak, NASA/GSFC - 2002 July

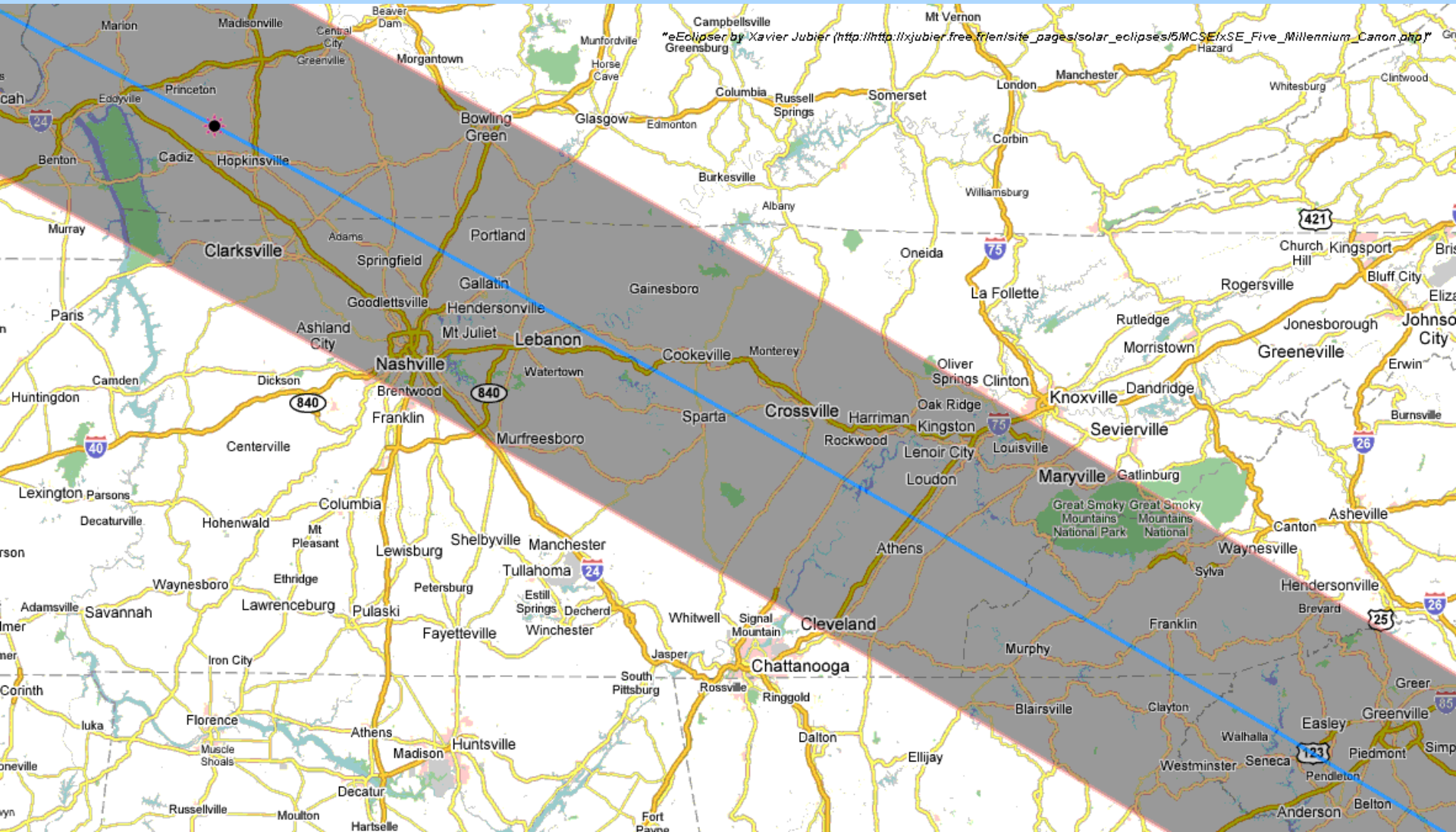
# The 21 August 2017 Total Solar Eclipse



# August 21, 2017 Total Solar Eclipse Path



# August 21, 2017 Total Solar Eclipse Path



# Do not Risk Your Precious Eyes!!

- Do ***not*** look at the partial phases of the eclipse directly without certified eye protection!!
- There's no point to staring at partial phases....
- Look without protection only if you're in the totality path, and then only during totality! (About 2 minutes.)



# Viewing Eclipses (partial phases)

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- Eclipse glasses:

(<https://eclipse.aas.org/resources/solar-filters>)



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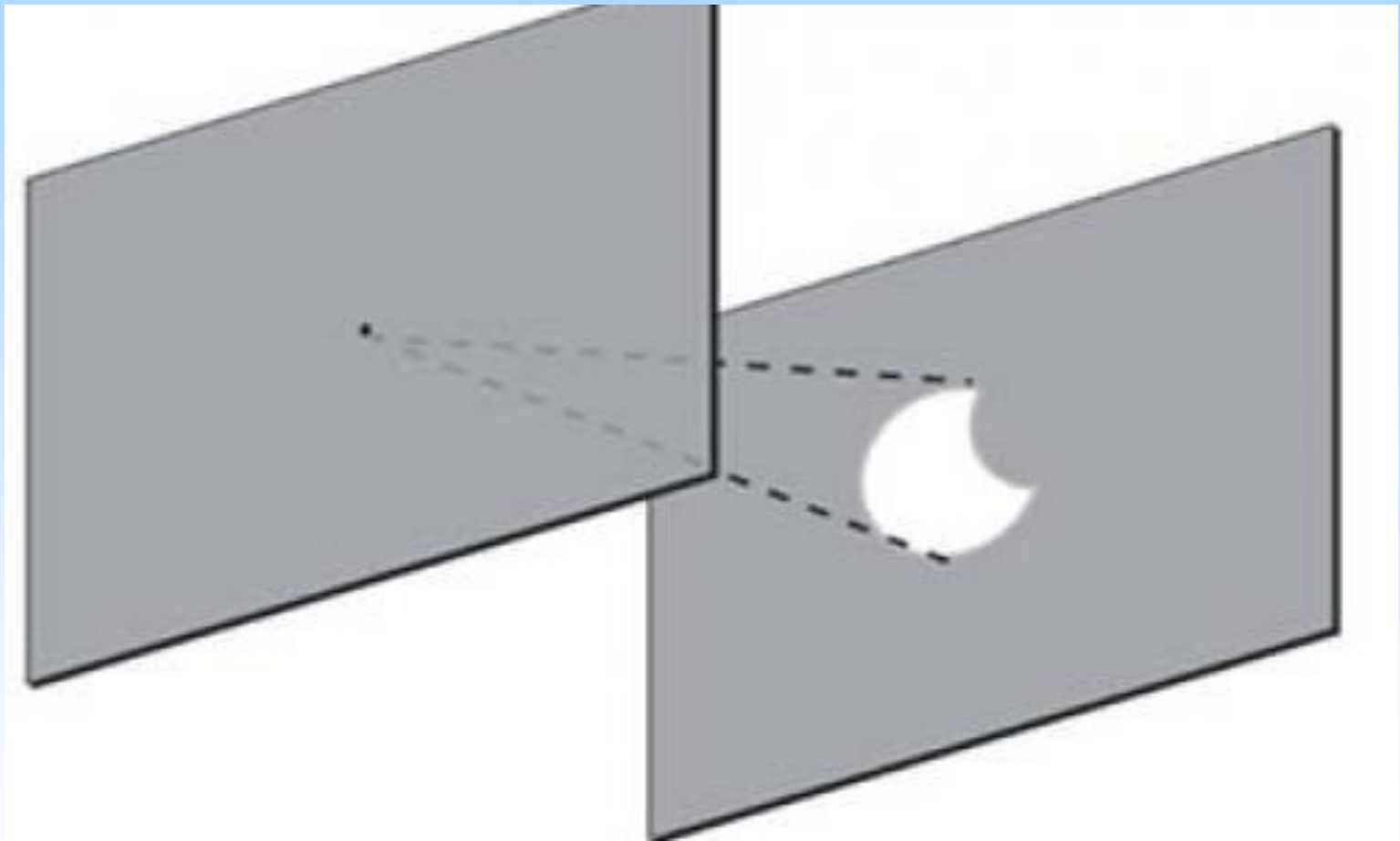
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- Indirect methods
  - Pinhole projection



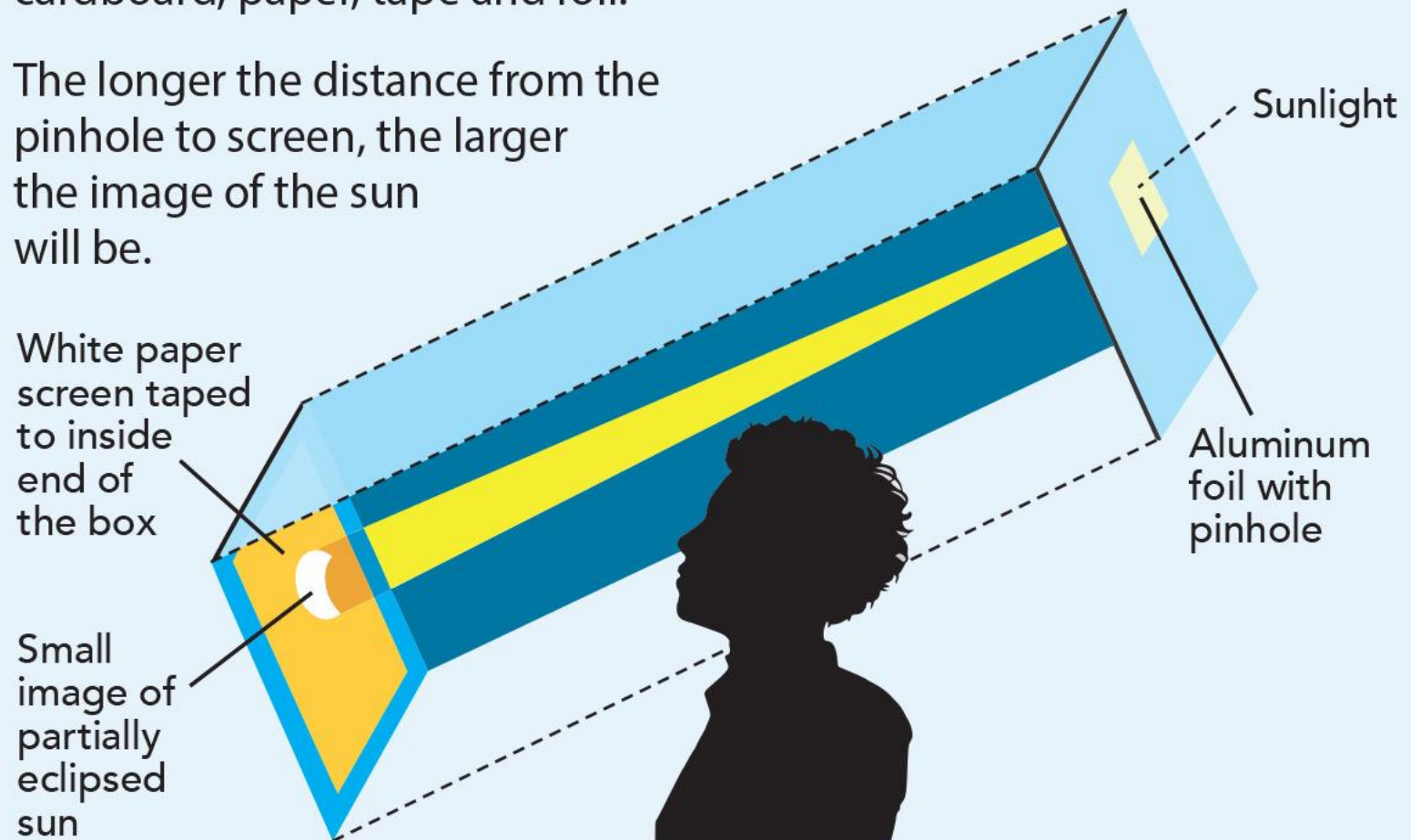
# Viewing Eclipses (partial phases)

- Eclipse glasses
- Welder's glass (#14)
- Indirect methods
  - Pinhole projection
  - Box projection

## MAKE YOUR OWN CARDBOARD PROJECTOR

You can make this simple eclipse projector with some cardboard, paper, tape and foil.

The longer the distance from the pinhole to screen, the larger the image of the sun will be.





# Viewing Eclipses (partial phases)

- Eclipse glasses
- Welder's glass (#14)
- Indirect methods
  - Pinhole projection
  - Box projection
  - Telescope/binocular projection

# Viewing Eclipses (partial phases)

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  - Telescope/binocular projection
  - Almost-anything projection!

# Eclipse Science

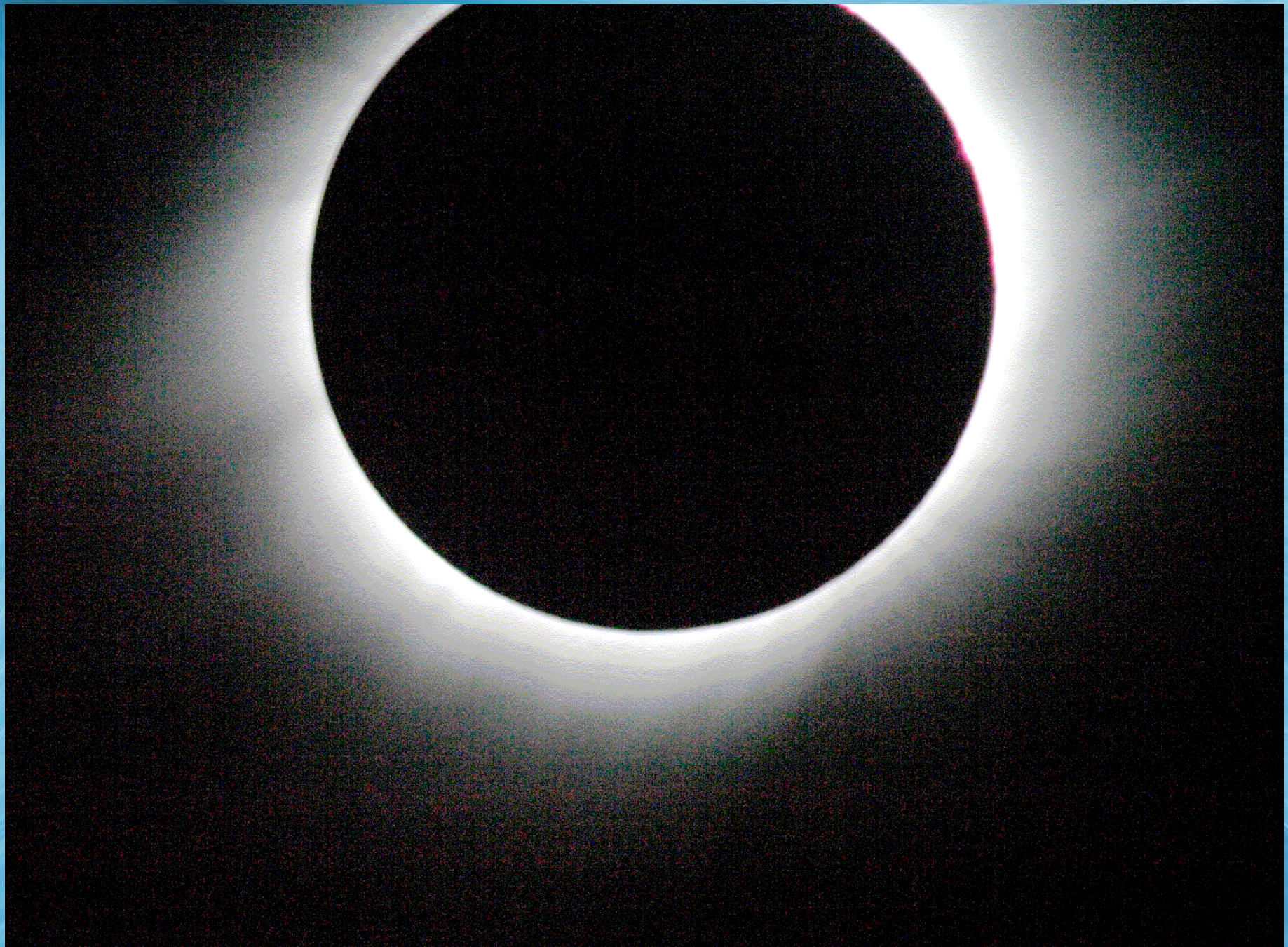
# How *Not* to do Eclipse Science! Ghana 2006 Version

(Useful information for picture takers too.)



















# Lessons Learned (Science at Eclipses)

- 🕒 No new equipment.
- 🕒 Consider carefully before moving after setting up.
- 🕒 Practice, practice, practice!





Gansu Province, China, 2008





















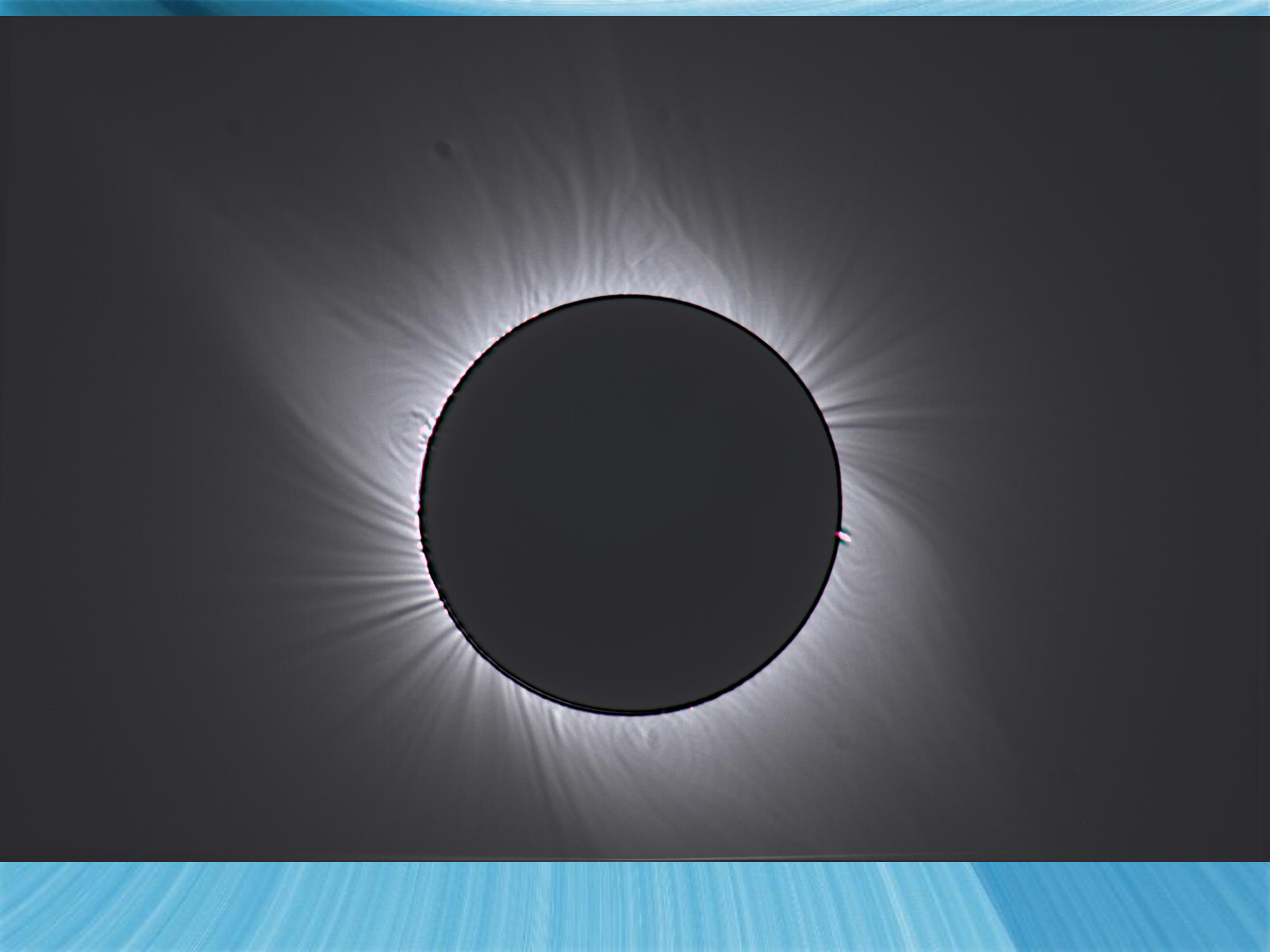












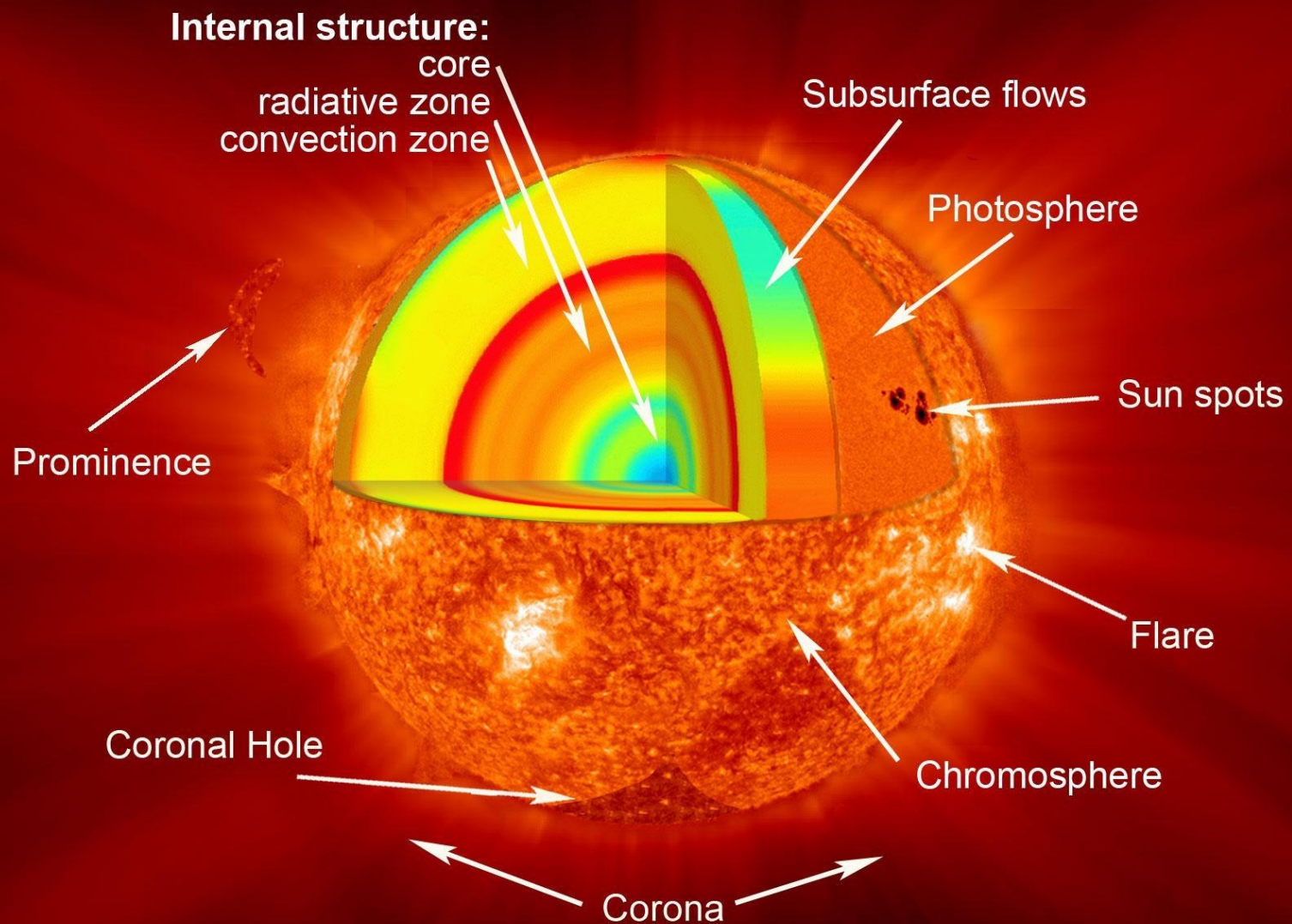




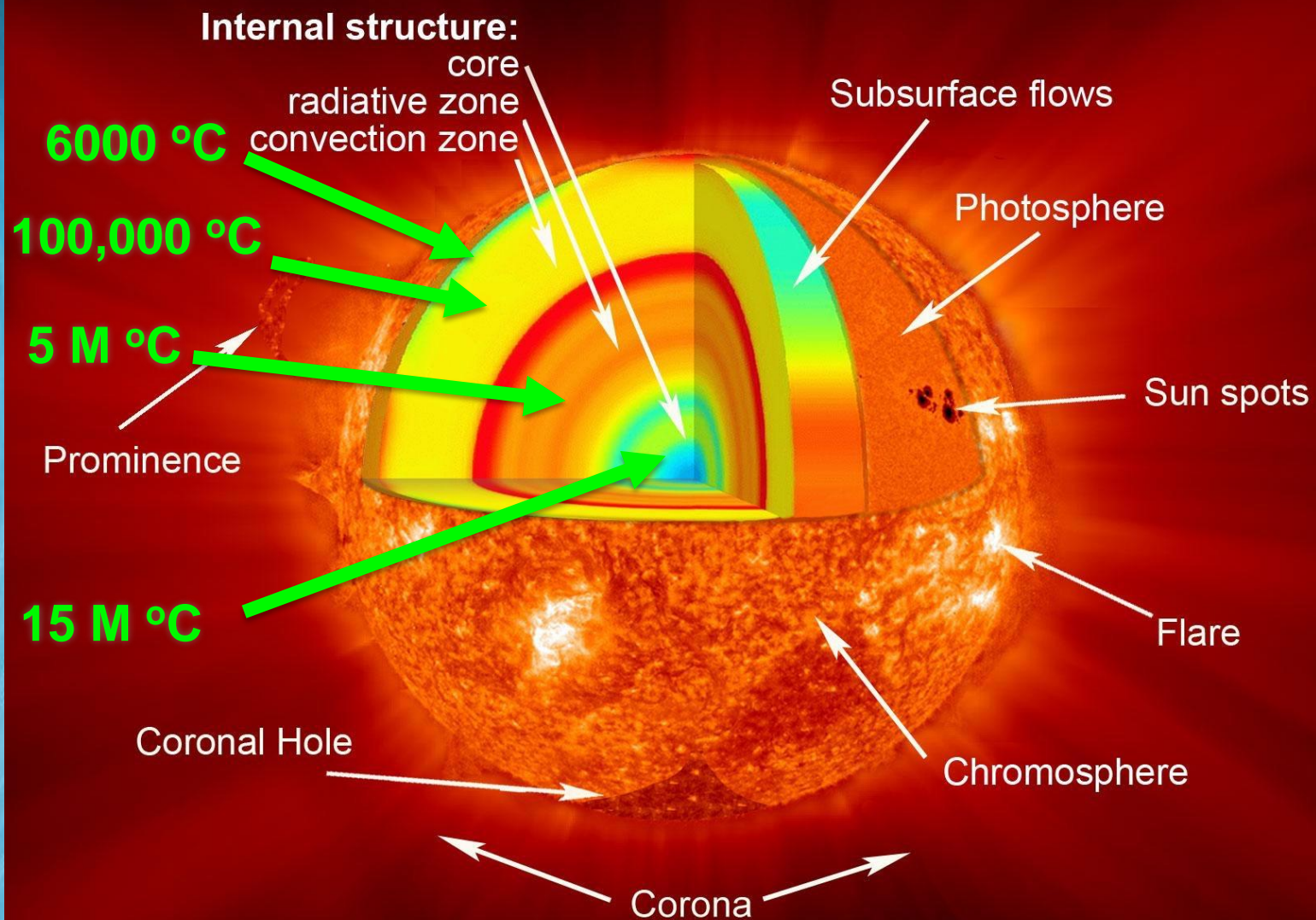




# Science of the Sun. A key Problem: The Temperature of the Corona



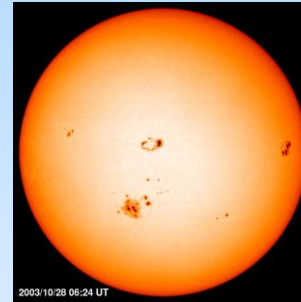




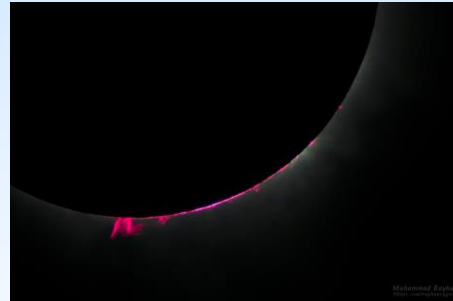
# The Solar Atmosphere

The Outer layers (Atmospheres) of the Sun:

- Photosphere



- Chromosphere



- Corona

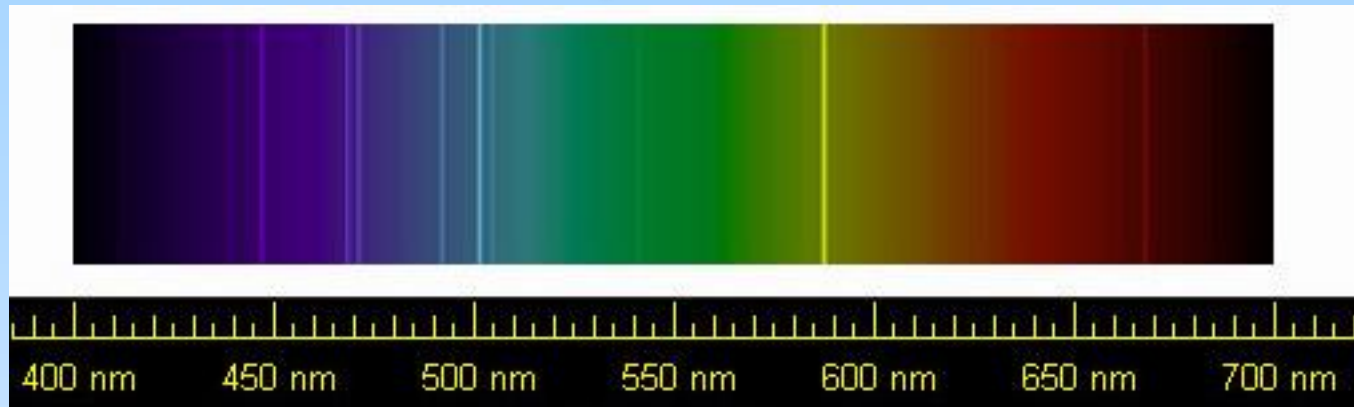




# But....

- A “problem” resulted from 1869 eclipse observations of the corona.
- Used a recently developed instrument - the “spectroscope,” to study the corona.

# Spectra



- Breaks light into “rainbow” colors, with lines.
- Different elements produce different lines.
- So these lines are like “fingerprints” for elements.



- Hence, spectra can be used to determine the composition of far-away objects, like the corona.

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But this didn't work....

# The Periodic Table

<div> <div>1</div> <div>H</div> <div>hydrogen</div> <div>1.007 94(7)</div> </div> <div> <div>Atomic Number</div> <div>Symbol</div> <div>Name</div> <div>Standard Atomic Weight</div> </div>																	
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
lithium	beryllium											boron	carbon	nitrogen	oxygen	fluorine	neon
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
sodium	magnesium											aluminum	silicon	phosphorus	sulfur	chlorine	argon
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
potassium	calcium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
rubidium	strontium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon
55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
cesium	barium	lanthanoids	hafnium	tantalum	tungsten	rhenium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon
87	88	89-103	104	105	106	107	108	109	110	111							
Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							
francium	radium	actinoids	rutherfordium	dupontium	seaborgium	bohrium	hassium	meitnerium	darmstadtium	roentgenium							
lanthanoids		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
		lanthanum	cerium	praseodymium	neodymium	promethium	samarium	euroium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium	
actinoids		89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	
		actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium	

NASA/CXC/SAO



# The Corona: Continued...

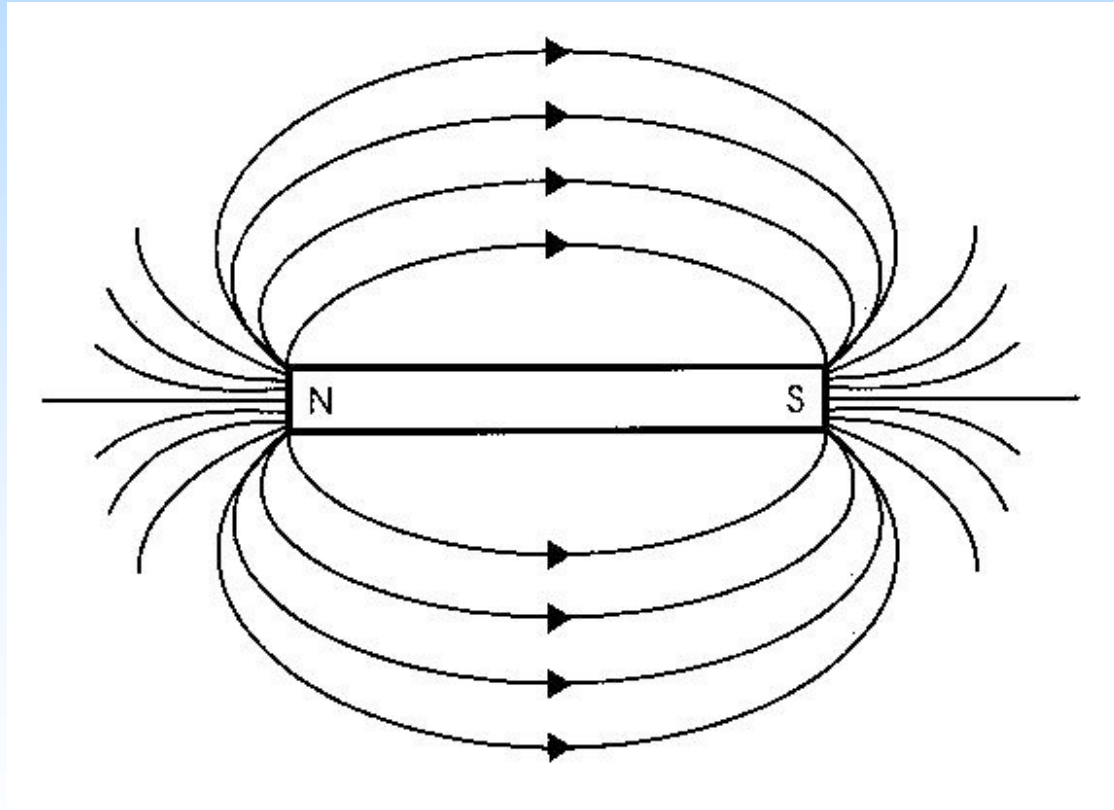
- The mystery spectral lines found to be due to very hot (“highly-ionized”) familiar elements ~1940.

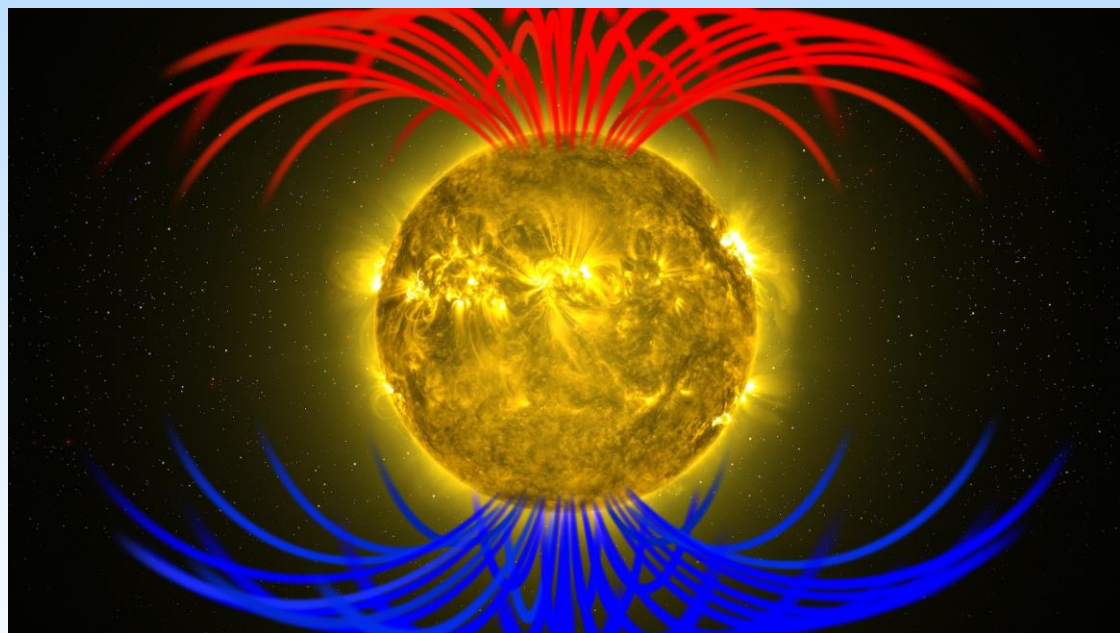
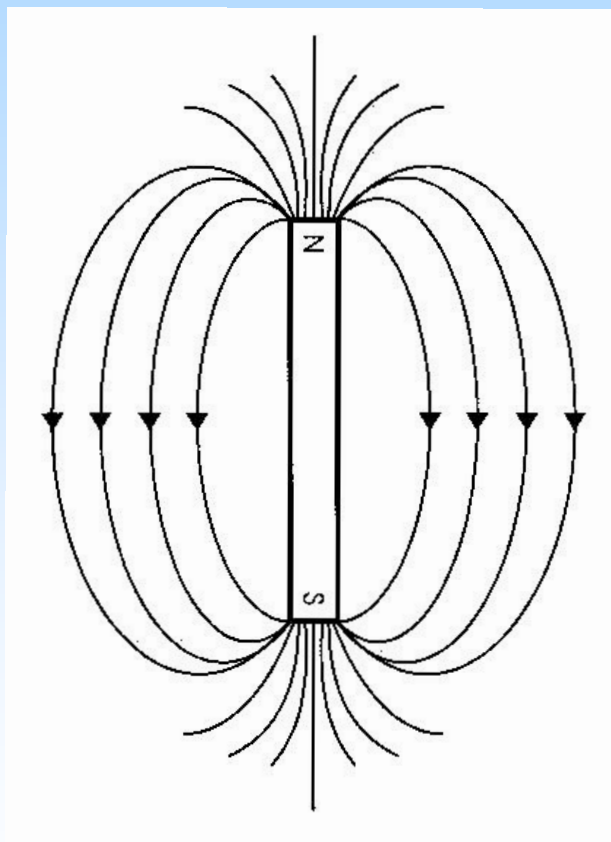
So this was a sloooooow process: 1869 eclipse observations, and 1939~1943 explanation!!

- Structure of the corona: late 1960s and 1970s observations from balloons, Skylab, etc.
- This structure due to the magnetic field.

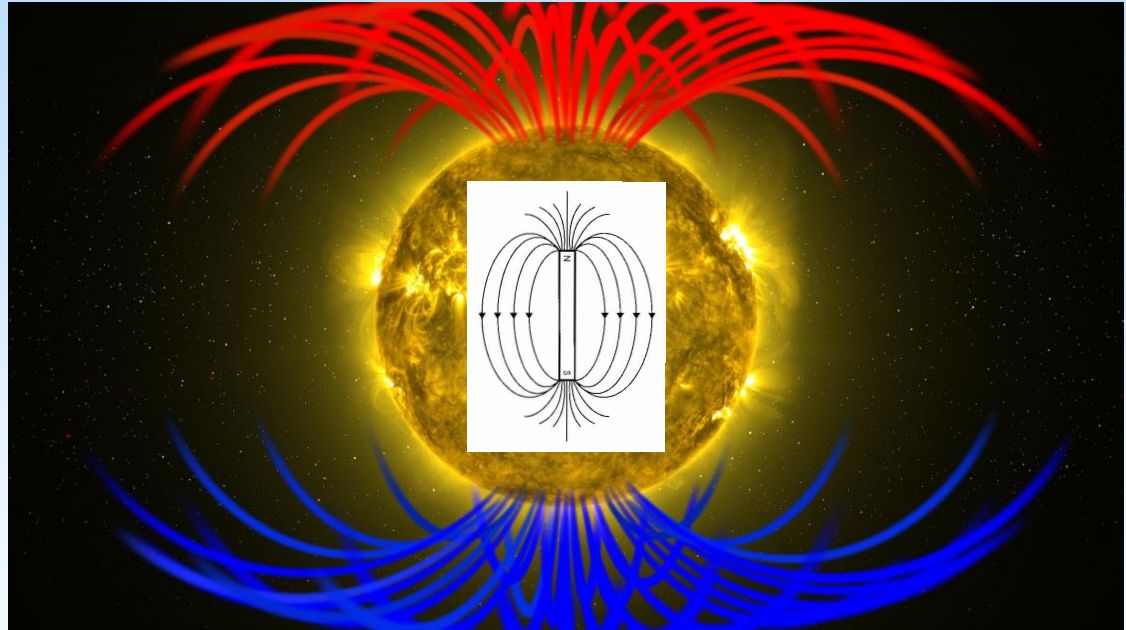
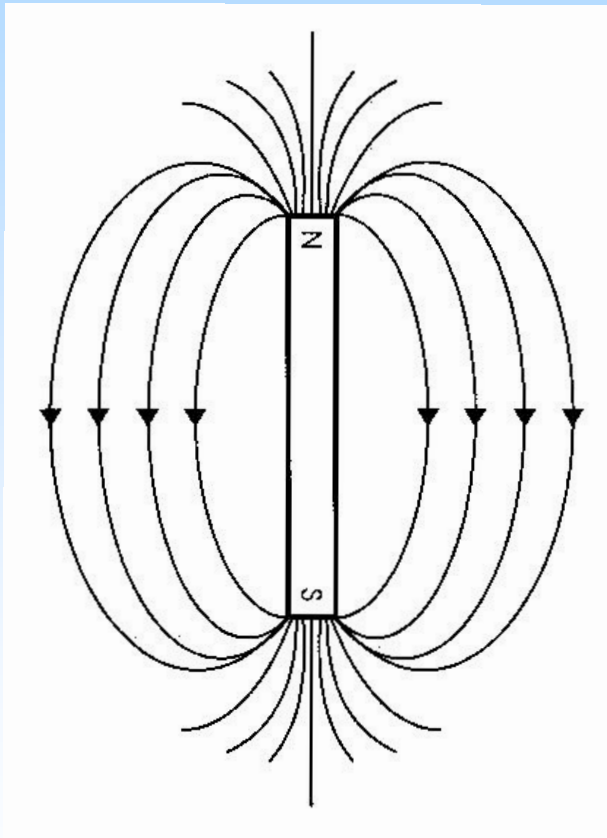


***Magnetism*** is the key to why the corona is hot. (It is also responsible for many of the changing features of the Sun.)

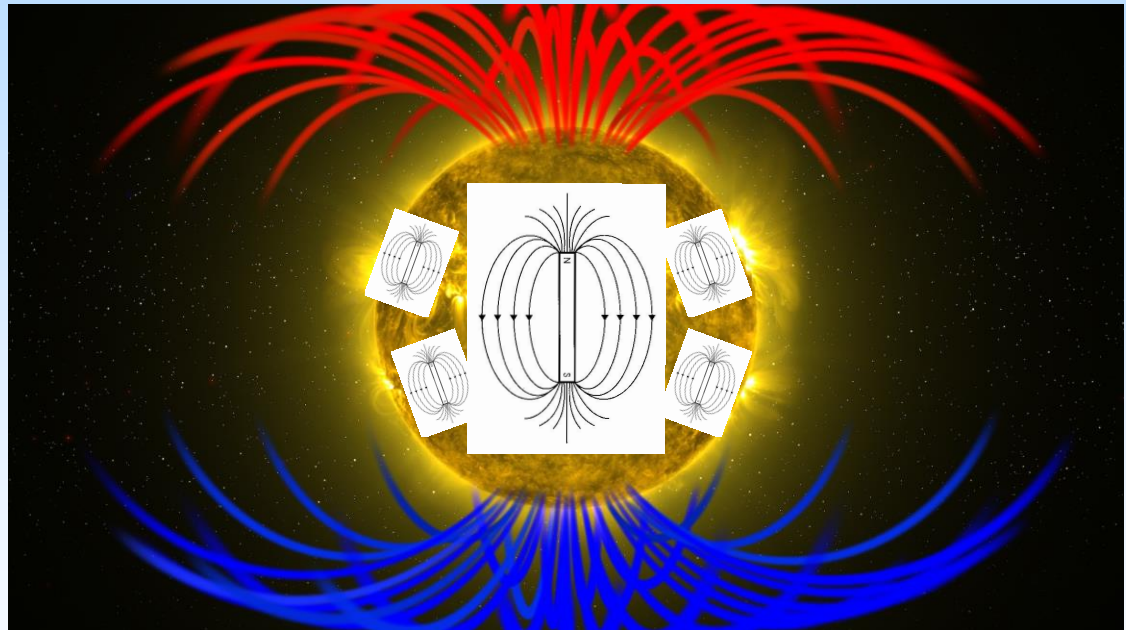
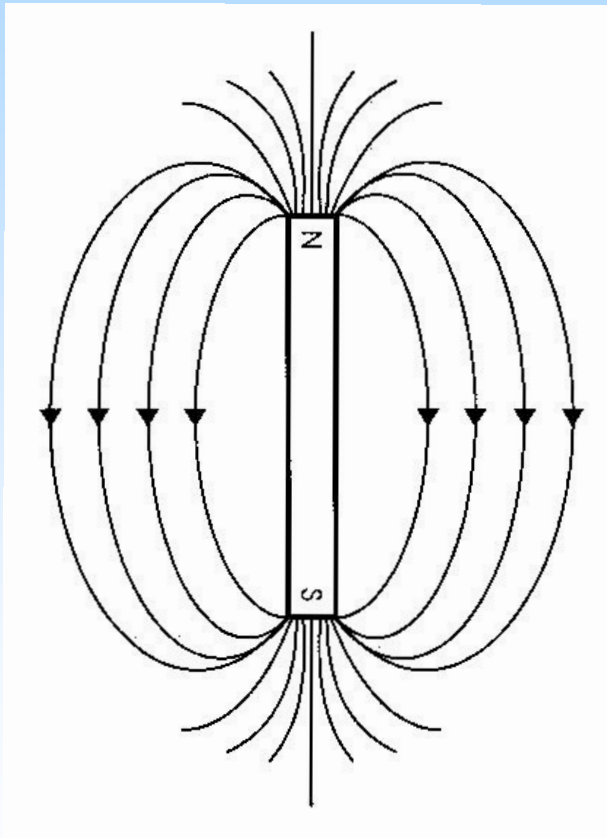




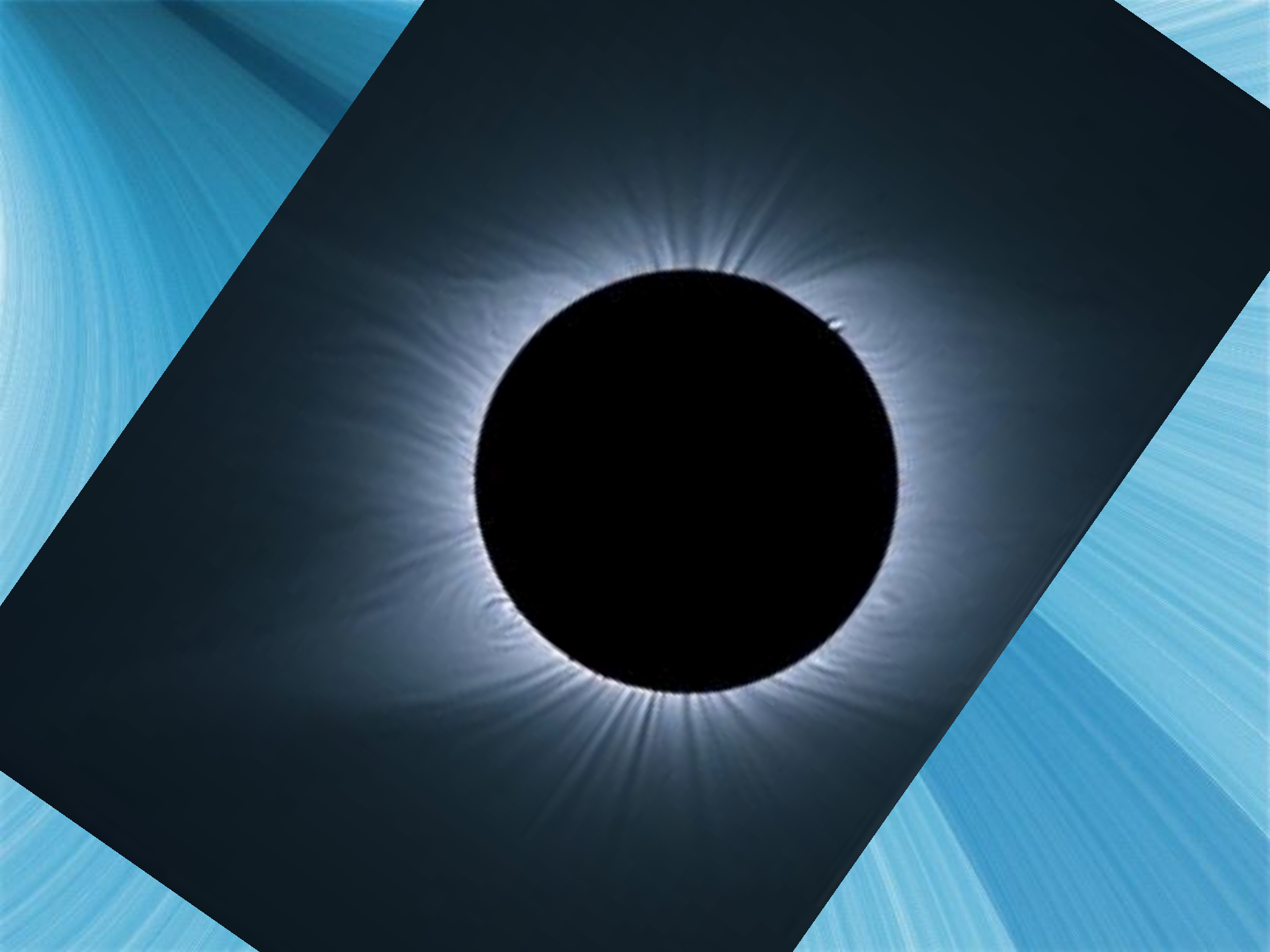
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***Magnetism*** is the key to why the corona is hot.







# A Key Objective of Solar Physics:

Unravel details of how the magnetic field heats the corona!

- This is one goal (direct or indirect) of many eclipse studies.
- Also, many other stars have hot coronae, and thus understanding the heating of the Sun's corona tells us about other stars too.



# Fun Things to Do:

- Temperature changes at different locations.
- Shadow bands, just near totality. Try taking pictures of them. (In path of totality.)
- Pictures of sharpening shadows. [To do “seriously”: Record time accurately (within a few seconds), your precise location (GPS coordinates?), use a standard surface (e.g., white sheet), sky conditions (may be hard unless clear).]
- Creative photography.



But maybe best of all...

But maybe best of all...

**ENJOY IT!**















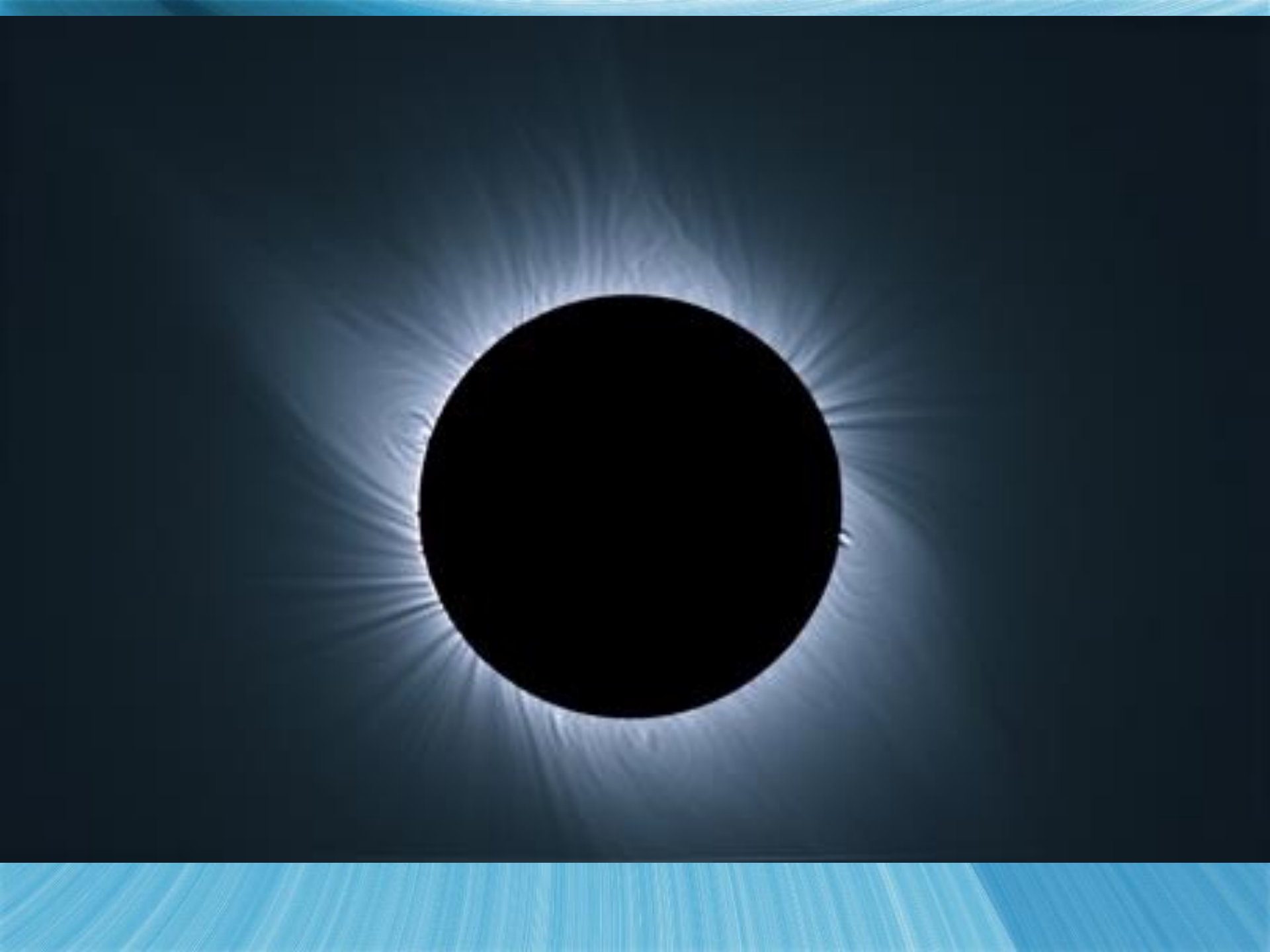


20 May 2012 22:35:22 UT



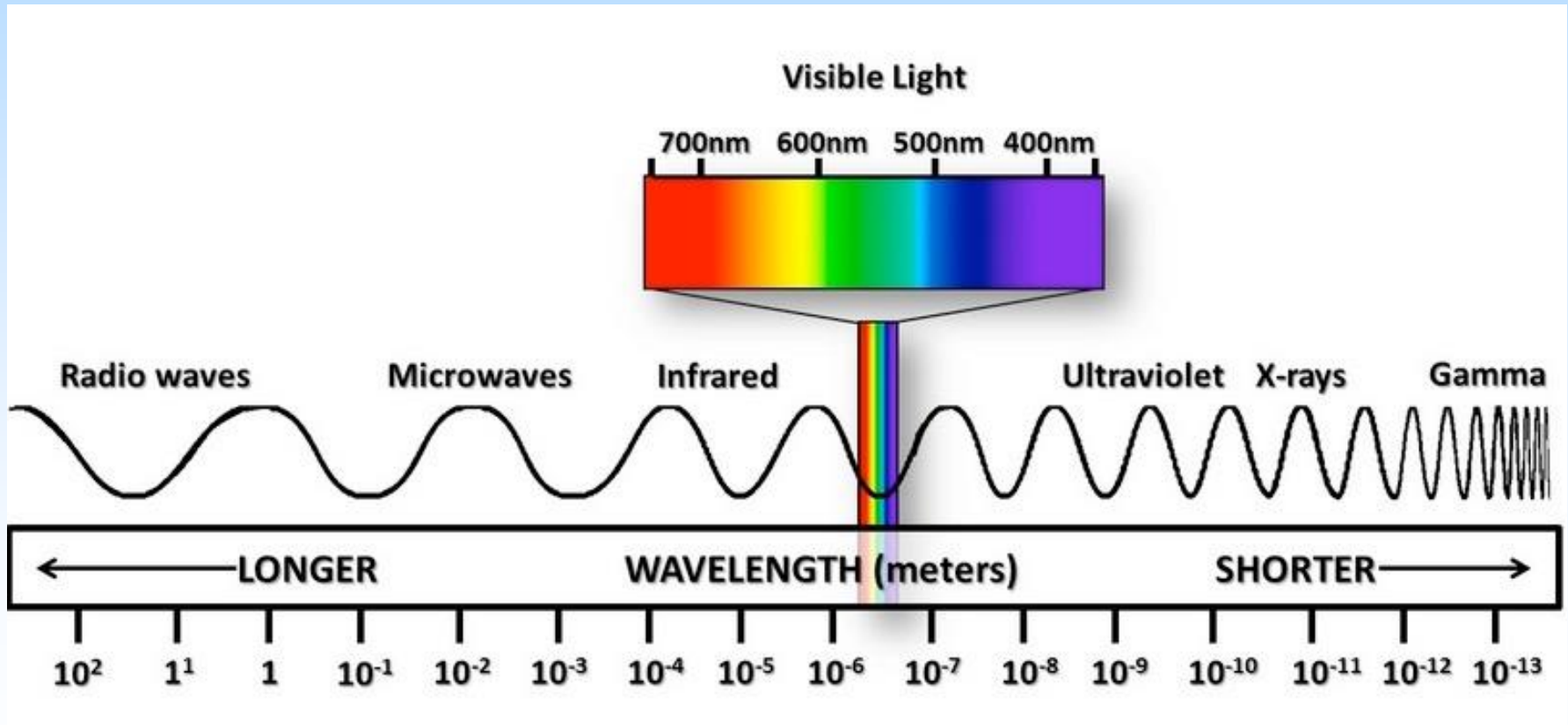




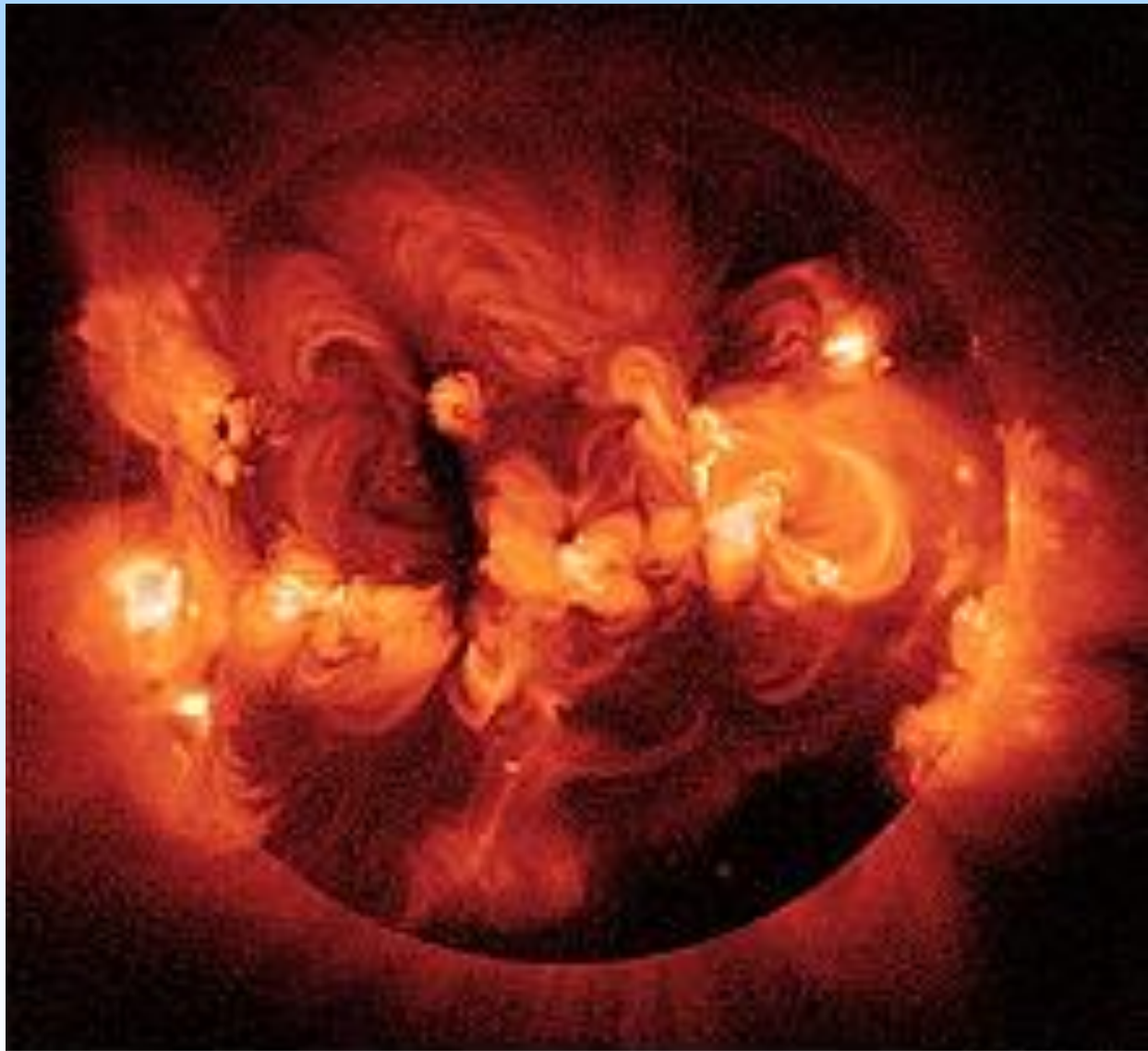




We have to go to *space* to see the Sun's outer atmosphere with regularity.

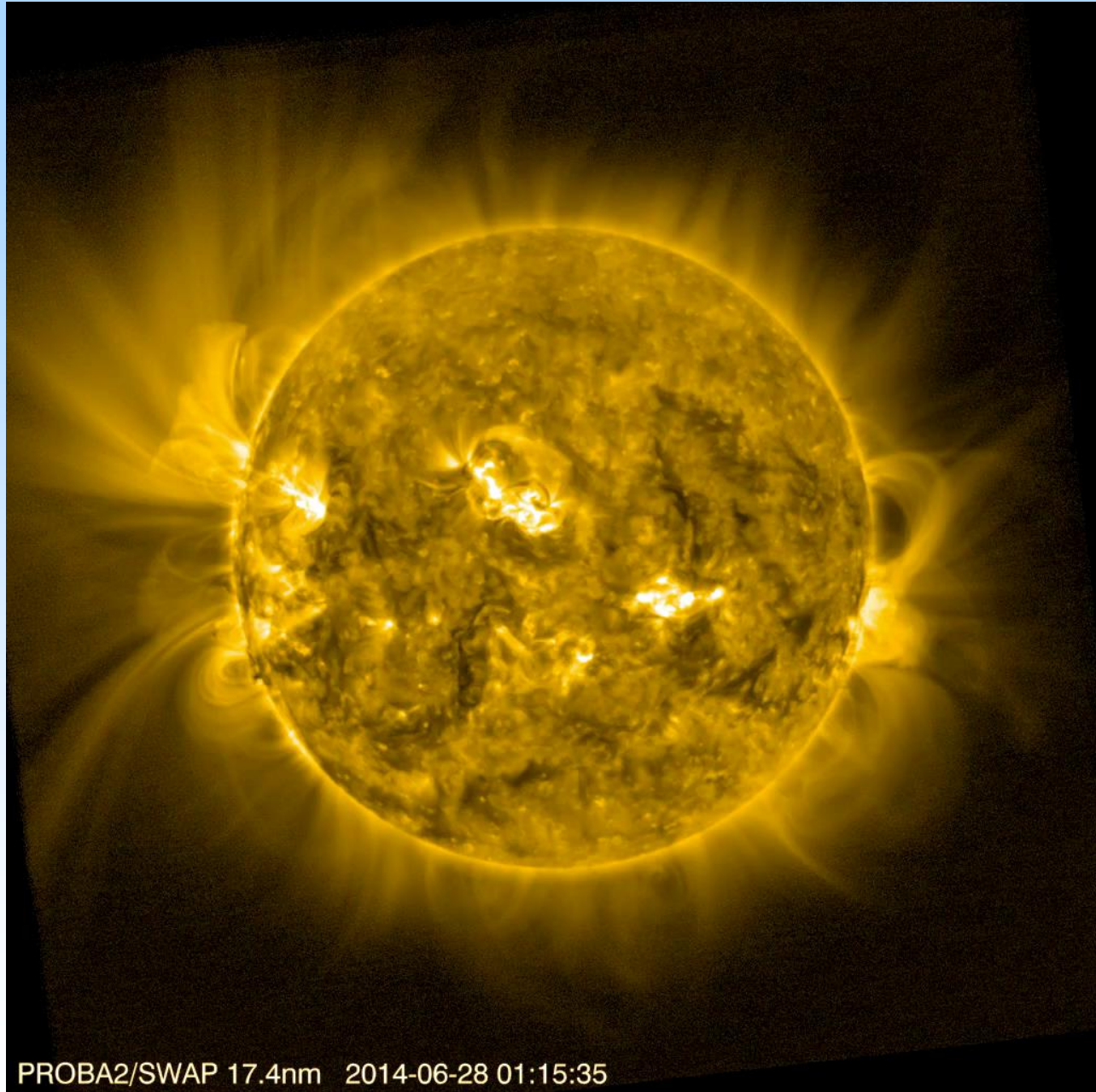






NASA

The Corona from Yohkoh/SXT



PROBA2/SWAP 17.4nm 2014-06-28 01:15:35

# The Corona

- Expected to be cool, but found strange spectral lines, first during 1869 eclipse.
- Many explanations considered, including a “new” element: *coronium*.
- **But this didn't work....**



# Annular Eclipse (2012)